

Updated distribution records of the *Anopheles* (*Anopheles*) *hyrcanus* species-group (Diptera: Culicidae) in China

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Abstract

Mosquito collections were carried out during July–August 2005 in China. The known distribution of *Anopheles hyrcanus* species-group in China is updated based on published records and original observations. Twenty-one of about 30 known species of the Old World Hyrcanus group (*Anopheles* subgenus *Anopheles*), including *An. belenrae* Rueda, were recorded in 24 provinces and 2 cities. *Anopheles sinensis* Wiedemann, recorded in 21 provinces and 2 cities, is the most widely distributed species, followed by *An. pullus* Yamada and *An. kweiyangensis* Yao and Wu. The status of the type specimens of some Hyrcanus group species and their importance in disease transmission are also noted.

Key words: *Anopheles*, Hyrcanus group, Diptera, Culicidae, mosquitoes, malaria, China

Introduction

The Old World *Anopheles hyrcanus* group consists of about 30 species (Harbach 2004, Ramsdale 2001). The group contains about three quarters of the species belonging to the Myzorrhynchus Series of the genus *Anopheles* subgenus *Anopheles* (Harbach 2004, Rueda 2005). Some species of this group are vectors of malarial parasites and other mosquito-borne diseases in the Oriental and Palearctic regions, in particular *An. sinensis* Wiedemann and *An. lesteri* Baisas and Hu in China and the Republic of Korea (Tanaka *et al.* 1979, Lu *et al.* 1997, Rueda *et al.* 2006).

In China, there are 21 known species of the Hyrcanus group: *An. argyropus* (Swellengrebel), *belenrae* Rueda, *changfui* Ma*, *crawfordi* Reid, *dazhaius* Ma*, *hailarensis* Xu and Luo*, *heiheensis* Ma*, *hyrcanus* (Pallas), *junlianensis* Lei*, *kiangsuensis* Xu and Feng*, *kunmingensis* Dong and Wang*, *kweiyangensis* Yao and Wu*, *lesteri* (junior synonym = *anthropophagus* Xu and Feng), *liangshanensis* Kang, Tan and Cao*, *nigerrimus* Giles, *nitidus* Harrison, Scanlon and Reid, *peditaeniatus* (Leicester), *pullus* Yamada, *sinensis**, *sineroides* Yamada, and *xiaokuanus* Ma*. The type localities of 11 species (with asterisks above) are in China (<http://www.mosquitocatalog.org/main.asp>).

Distribution records for Hyrcanus group in China are incomplete or unavailable, particularly data for specimens deposited in various museums. Rueda *et al.* (2005a) reported on the distribution of *An. sinensis* based on specimens deposited in the Chinese Academy of Science museum, Beijing, and on published

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records. Ma & Yu (1993) listed 15 species of the group in their records from China, while Lu and Yong (2003) included 8 species from several provinces. We conducted this study to determine the distribution of Hyrcanus group species in China based on museum specimens, published reports, and our field collections.

Material and methods

Field collections. Our 26 mosquito collections in China during July and August 2005 resulted in 247 individually reared pinned adults, 118 individually reared adults preserved in 100% ethyl alcohol for molecular tests (204 of those reared adults with exuviae of larvae and pupae), and 109 whole larvae. Larval and pupal skins were slide mounted using standard protocols (Walter Reed Biosystematics Unit 2001). Concurrently, two type localities and two sites near type localities were sampled for mosquitoes in 2005, i.e. Kunming, Yunnan for *An. kunmingensis*; Guiyang, Guizhou for *An. kweiyangensis*; Jiangsu for *An. kiangsuensis*; and Sichuan for *An. liangshanensis*. We initially targeted larval collections from habitats where *Anopheles* were likely to occur, such as rice paddies, vegetable fields, irrigation ditches, roadside and drainage ditches, stream margins and pools, ground or drain pools, ponds, and others. Larvae and pupae were collected using dippers and then reared individually to the adult stage (Walter Reed Biosystematics Unit 2001). Adult *Anopheles* were collected by mouth aspirators in rural villages using mesh-screened mosquito nets (182 x 122 x 122 cm), with light attractant outside the net, and indoors and outdoors from dwelling walls. Voucher specimens are deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D. C.

Museum specimens. Specimens of Hyrcanus group species deposited at three institutions were examined, namely Institute of Zoology Museum (Chinese Academy of Science, Beijing), Entomology Museum (Institute of Microbiology and Epidemiology, Beijing) and Entomology Collection Laboratory (Department of Etiologic Biology, Second Military Medical University, Shanghai). Coordinates for collection sites of museum specimens were recorded using gazetteers of the U. S. Board of Geographic Names (1979) and the Global Gazetteer (2006).

Mosquito identifications. Adult specimens and associated larval/pupal exuviae of both field-collected and museum specimens were identified using morphological characters in Tanaka *et al.* (1979), Ma & Yu (1993) and Lu *et al.* 1997, and some field-collected specimens were confirmed using an rDNA ITS2-based method (Wilkerson *et al.* 2003).

Results and discussion

The distribution of the Hyrcanus group in China is shown in Figure 1. Twenty-one species of the group were found in 24 provinces and 2 cities (Beijing and Shanghai), with Yunnan having the highest number of species (7), followed by Liaoning (6) and Sichuan (6), and the remaining provinces with 1–4 species (Tables 1 and 2). *Anopheles sinensis*, the most widespread species of the group in China, was recorded from 21 provinces and 2 cities. *Anopheles lesteri* (= *anthropophagus*, Ma 1981), the second most widespread species, was found in 15 provinces, followed by *An. pullus* (12 provinces) and *An. kweiyangensis* (11 provinces). Other species are recorded from 1–5 provinces.

Although *An. sinensis* is considered an important vector of malaria in China, particularly in rice producing areas (Lu *et al.* 1997), it is considered about 20 times less susceptible than *An. lesteri* (as *An. anthropophagus*) (Liu *et al.* 1990). *Anopheles sinensis* is common in rice fields, ditches (irrigation/roadside/drainage), stream pools, stream margins, road tracks, and other habitats (Tanaka *et al.* 1979, Lu & Yong 2003, Rueda *et al.* 2006). During our survey, we collected the larvae and pupae of *An. sinensis* from small creeks, rice paddies, irrigation ditches, irrigated sugar cane and vegetable fields (primarily corn, string beans, soybeans and crucifers), ground pools, and permanent ponds. In 2005, the mean water temperature (27.4°C), conductivity (0.54 uS) and salinity (0.35 ppm) of larval/pupal habitats in rice paddies were greater than in the surrounding irriga-

tion ditches (25.1 °C, 0.16 uS, and 0.33 ppm, respectively); however, the mean pH (7.35, 7.33) in both habitats was essentially equal. In the irrigation ditches of vegetable fields, mean temperature, conductivity, salinity and pH were 28.2 °C, 0.72 uS, 0.35 ppm and pH 7.4, respectively.

Anopheles lesteri (as *An. anthropophagus*), the primary vector of malaria in China, is susceptible to infections of both *Plasmodium vivax* and *P. falciparum* (Lu *et al.* 1997). In addition to being an important vector of filarial worm, *Brugia malayi*, in China, it can be artificially infected with *Wuchereria bancrofti* in the laboratory (Lu *et al.* 1997).

Other potential vectors of malaria in China include *An. kunmingensis* and *An. hyrcanus* (Lu *et al.* 1997). *Anopheles pullus* is not known as a malaria vector in China, unlike in South Korea (Shin *et al.* 2002, Hong 1977). *Anopheles pullus*, *An. liangshanensis* and *An. kweiyangensis* are potential vectors of filariasis in various parts of China, with the first 2 species a major threat in Sichuan Province (Lu *et al.* 1997).

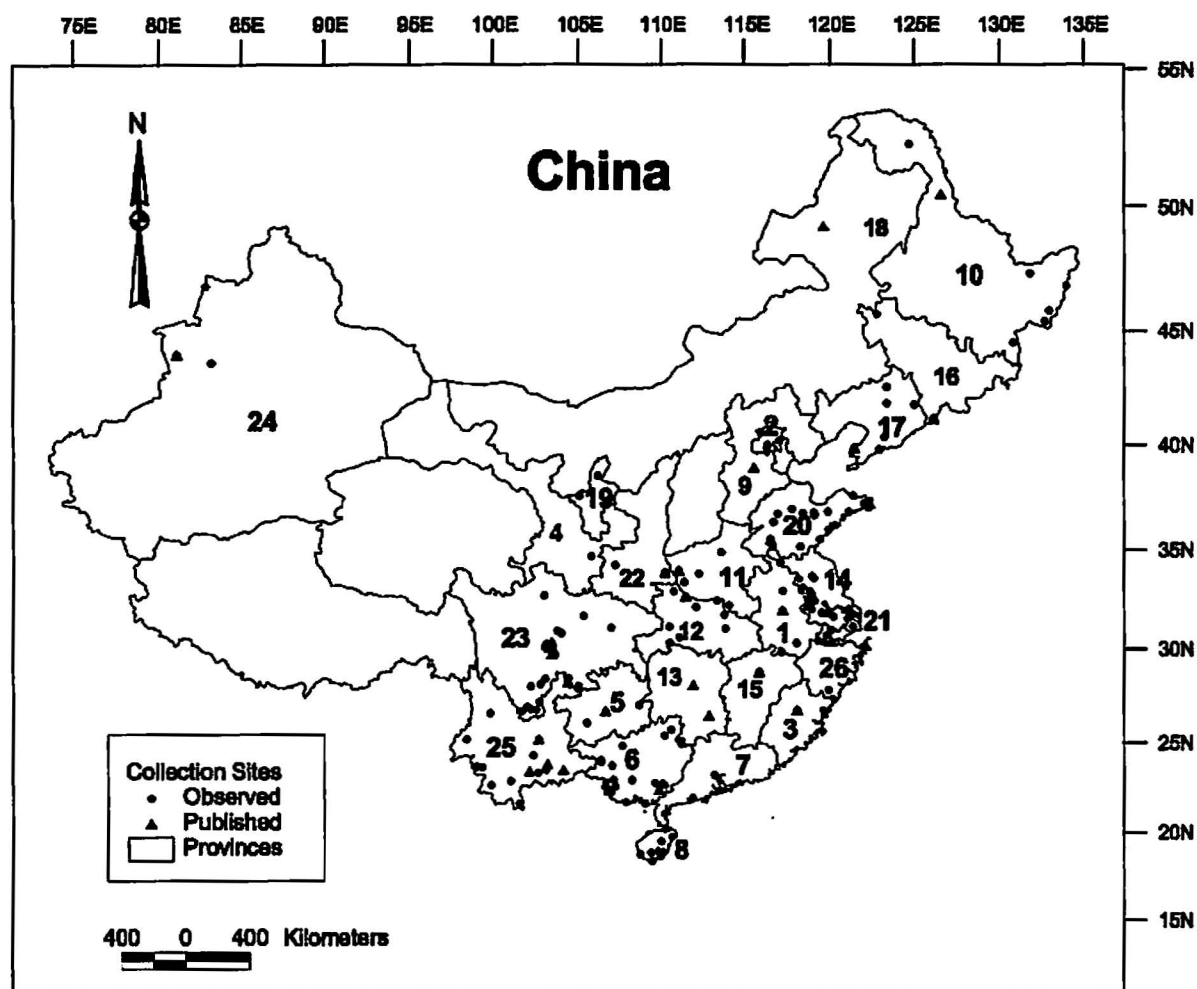


FIGURE 1. Map of mainland China showing the distribution of *Anopheles hyrcanus* group (based on observed and published specimens). Province Identification: (1) Anhui, (2) Beijing (3) Fujian, (4) Gansu, (5) Guangdong, (6) Guangxi, (7) Guizhou, (8) Hainan, (9) Hebei, (10) Heilongjiang, (11) Henan, (12) Hubei, (13) Hunan, (14) Jiangsu, (15) Jiangxi, (16) Jilin, (17) Liaoning, (18) Inner Mongol, (19) Ningxia, (20) Shandong, (21) Shanghai, (22) Shaanxi, (23) Sichuan, (24) Xinjiang, (25) Yunnan, (26) Zhejiang.

TABLE 1. Summary of collection localities for *Anopheles Hyrcanus* Group species (based on observed specimens) in China.

Anopheles Species	Province: Locality	Collection date	No. and stage ¹	Grid Coordinates ²			Repository ³
				Latitude	Longitude		
<i>belenrae</i>	Liaoning: Donggang	Aug 1998	D	39.77	N 121.50	W	SM
<i>belenrae</i>	Shandong: Jining	Jul 1997; Aug 2000	D	35.41	N 116.58	W	SM
<i>crawfordi</i>	Yunnan: Mengla	Nov 1998	1F	21.47	N 101.58	W	SM
<i>dazhaius</i>	Sichuan: Chengdu	18 Jun 1982	20L	30.67	N 104.07	W	IM
<i>hyrcanus</i>	Xinjiang: Yili	Aug 1957	1F	43.52	N 83.30	W	IM
<i>hyrcanus</i>	Xinjiang: Yining	Jul 1999	D	43.88	N 81.25	W	SM
<i>hyrcanus</i>	Xinjiang: Yining	1995	2F, 1M	43.88	N 81.25	W	SM
<i>junlianensis</i>	Sichuan: Hongya	Aug 1997	D	29.93	N 103.42	W	SM
<i>junlianensis</i>	Sichuan: Pujiang	Sep 1994	D	30.20	N 103.50	W	SM
<i>kunmingensis</i>	Sichuan: Chengdu	16 Jan 1989	3F	30.67	N 104.07	W	SM
<i>kunmingensis</i>	Yunnan: Longling	Feb 1989	2L, 1P	24.58	N 98.68	W	SM
<i>kunmingensis</i>	Yunnan: Tengchong	Dec 1981; 1989; Aug 1997	9F, 2M; 4L	25.03	N 98.47	W	IM
<i>kweiyangensis</i>	Guizhou: Guanling	Sep 1994	3F, 1M	25.95	N 105.63	W	SM
<i>kweiyangensis</i>	Guizhou: Guiyang	Aug 1988; 1961	1L, 1P; 1F, 1M	26.92	N 108.73	W	SM
<i>kweiyangensis</i>	Henan: Xinyang	8 Jul 1973; 1973; 30 Jul 1978	2F; 4L; 1M	32.10	N 114.12	W	IM
<i>kweiyangensis</i>	Liaoning: Xiuyan	24-25 Jul 1958	2F	40.29	N 123.27	W	IM
<i>kweiyangensis</i>	Sichuan: Leshan	May 1956	2F	29.57	N 103.73	W	IM
<i>kweiyangensis</i>	Sichuan: Pujiang	1 Sep 1994; Apr 1997	4F	30.20	N 103.50	W	SM
<i>kweiyangensis</i>	Sichuan: Yaan	31 Jul; 2-3 Aug 1975	3M; 1M, 4F	29.98	N 103.08	W	IM
<i>kweiyangensis</i>	Zhejiang: Zhoushan	30 May, 8 Jun, 2 July, 1953; 25 Aug, 14 Sep 1953	4F; 1M	30.02	N 122.10	W	IM
<i>lesteri</i>	Guangdong: Guangzhou	1 Jan, Nov 2003	10F	23.12	N 113.25	W	SM
<i>lesteri</i>	Guangdong: Zhuhai	Jul 2002	1F	22.28	N 113.57	W	SM
<i>lesteri</i>	Guangdong: Heng-qing Island, Zhuhai	Nov 2004	4F	22.28	N 113.57	W	FC
<i>lesteri</i>	Guangxi: Bobai	No date	1F	22.28	N 109.97	W	SM
<i>lesteri</i>	Hainan: Wenchang	No date	1F	19.62	N 110.75	W	SM
<i>lesteri</i>	Henan: Tanghe	Jul 1999	1F	33.85	N 111.12	W	SM
<i>lesteri</i>	Henan: Tongbai	Jul 1999	1F	32.36	N 113.40	W	SM
<i>lesteri</i>	Henan: Xinyang	Jul 1999	1F	32.10	N 114.12	W	SM
<i>lesteri</i>	Jiangsu: Huaian	Nov 2004	3F	33.50	N 119.14	W	FC
<i>lesteri</i>	Jiangsu: Wuxi	14, 16 May 1987	47F, 50M	31.58	N 120.29	W	IM
<i>lesteri</i>	Liaoning: Donggang	Aug 1997	D	39.77	N 121.50	W	SM

to be continued.

TABLE 1. (continued)

Anopheles Species	Province: Locality	Collection date	No. and stage ¹	Grid Coordinates ²			Repository ³
				Latitude	Longitude		
<i>lesteri</i>	Liaoning: Faku	Sep 1996	D	42.50	N 123.41	W	SM
<i>lesteri</i>	Liaoning: Shenyang	Aug 1998	D	41.79	N 123.43	W	SM
<i>lesteri</i>	Liaoning: Zhuanghe	Aug 1999	D	39.70	N 122.99	W	SM
<i>lesteri</i>	Yunnan: Weixin	Aug 1999	D	27.80	N 105.08	W	SM
<i>liangshanensis</i>	Sichuan: Chengdu	2 Jun 1982	1Ge	30.67	N 104.07	W	IM
<i>liangshanensis</i>	Sichuan: Chengdu	1 Jan 1989	3F, 1M, 2L	30.67	N 104.07	W	SM
<i>liangshanensis</i>	Sichuan: Chengdu	No date	7F, 3M	30.67	N 104.07	W	IM
<i>liangshanensis</i>	Sichuan: Chengdu	28 Apr 1982	3L, 3Pe, 2Ge	30.67	N 104.07	W	IM
<i>liangshanensis</i>	Sichuan: Zhaojiao Co., Yuan, Liangshan	1 Jun 1997	4F	27.90	N 102.27	W	SM
<i>liangshanensis</i>	Sichuan: Zhaojue	Jun 1997	D	28.02	N 102.85	W	SM
<i>liangshanensis</i>	Yunnan: Tengchong	Aug 1997	1F	25.03	N 98.47	W	IM
<i>nigerrimus</i>	Yunnan: Kunming	No date	3F, 1M	25.04	N 102.72	W	IM
<i>peditaeniatus</i>	Fujian: Nanping	25 Aug 1959	1F	26.65	N 118.17	W	IM
<i>peditaeniatus</i>	Guangxi: Daxin	1 Oct 1957	1F	22.84	N 107.20	W	IM
<i>peditaeniatus</i>	Guangxi: Longzhou	13 Sep 1974	1F	22.35	N 106.86	W	IM
<i>peditaeniatus</i>	Guangxi: Mobian	20 Jun 1967	1F	22.45	N 107.31	W	IM
<i>peditaeniatus</i>	Hainan: Diaoluoshan	7 Apr 1974	1F	18.80	N 109.88	W	IM
<i>peditaeniatus</i>	Hainan: Qiongzhou	12 Jul 1974	1F	20.06	N 110.35	W	IM
<i>peditaeniatus</i>	Hainan: Tunchang	12 Sep 1956	8F	19.36	N 110.10	W	IM
<i>peditaeniatus</i>	Hainan: Wenchang	9 Sep 1956	3F	19.62	N 110.75	W	IM
<i>peditaeniatus</i>	Hainan: Wenhua, Haikou	7 Jun 1974	1F	20.05	N 110.34	W	IM
<i>peditaeniatus</i>	Hainan: Xinglong	12 Sep 1956	2F	18.75	N 110.20	W	IM
<i>peditaeniatus</i>	Yunnan: Gengma	2 Jul 1954	1F	23.52	N 99.40	W	IM
<i>peditaeniatus</i>	Yunnan: Mengding	27 Jul 1953	2F	23.55	N 99.08	W	IM
<i>peditaeniatus</i>	Yunnan: Mengla	27 Jul 1953; Aug 2001	1F	21.47	N 101.58	W	IM
<i>peditaeniatus</i>	Yunnan: Shuangjiang	15 Jul 1953; 2 Jul 1954	1F; 7F	24.17	N 102.40	W	IM
<i>pullus</i>	Guizhou: Ergezai, Guiyang	12 Aug 2005	1M, 1L	26.58	N 106.72	W	FC
<i>pullus</i>	Heilongjiang: Hurao	Jul, Aug 1961; 18 Sep 1980	3F	45.77	N 132.99	W	IM
<i>pullus</i>	Heilongjiang: Raohe	24 Jul 1992	1F	46.80	N 134.02	W	IM
<i>pullus</i>	Heilongjiang: Suib- ing	14 Aug 1971	1F	47.29	N 131.86	W	IM
<i>pullus</i>	Heilongjiang: Suiy- ang	6 Aug 1971	1F	44.43	N 130.88	W	IM

To be continued.

TABLE 1. (continued)

Anopheles Species	Province: Locality	Collection date	No. and stage ¹	Grid Coordinates ²			Repository ³
				Latitude	Longitude		
<i>pullus</i>	Heilongjiang: Xing-kaihu	8, 13 Jun, 12, 17 Jul 1971	4F	45.30	N 132.77	W	IM
<i>pullus</i>	Henan: Tanghe	Jul 2001	1F	33.85	N 111.12	W	SM
<i>pullus</i>	Liaoning: Donggang	Aug 1997	D	39.77	N 121.50	W	SM
<i>pullus</i>	Liaoning: Shenyang	Aug 1998	D	41.79	N 123.43	W	SM
<i>pullus</i>	Liaoning: Xinbin	14 Jul 1991	1F	41.72	N 125.04	W	IM
<i>pullus</i>	Shandong: Jining Co.	25 Jul 2005	3F, 1M	35.41	N 116.58	W	SM
<i>pullus</i>	Sichuan: Gaoxian	No date	D	28.35	N 104.52	W	SM
<i>pullus</i>	Sichuan: Junlian	No date	D	28.13	N 104.48	W	SM
<i>pullus</i>	Sichuan: Pujiang	Sep 2004	4F	30.20	N 103.50	W	SM
<i>sinensis</i>	Anhui: Fucunniufang	12 Jul 1989	3 F	29.73	N 117.24	W	CA
<i>sinensis</i>	Anhui: Furen	12 Jul 1989	3 F	31.85	N 117.28	W	CA
<i>sinensis</i>	Anhui: Furenfang	8 Jul 1989	1 F	32.85	N 117.28	W	CA
<i>sinensis</i>	Anhui: Huangshan	25 Jun 1989	1 F	30.17	N 118.12	W	CA
<i>sinensis</i>	Anhui: Shuifutian	12 Jul 1989	2 F	32.68	N 118.98	W	CA
<i>sinensis</i>	Beijing: Beijing	4-28 June 1957	135 F	39.93	N 116.39	W	CA
<i>sinensis</i>	Beijing: Daxing	12-14 Aug 1970	12 F	39.72	N 116.33	W	CA
<i>sinensis</i>	Beijing: Pinggu	24 Jun 1974	12 F, 1 M	40.13	N 117.12	W	CA
<i>sinensis</i>	Beijing: Yianqing	25 Jun 1974	13 F, 1 M	40.47	N 115.97	W	CA
<i>sinensis</i>	Fujian: Nanping	No date	1F	26.65	N 118.17	W	CA
<i>sinensis</i>	Gansu: Tianshui	14, 18 Jun 1972	3F	34.58	N 105.89	W	SM
<i>sinensis</i>	Gansu: Tianshui	26-27 Jul 1972	4F	34.58	N 105.89	W	SM
<i>sinensis</i>	Guangdong: Daling	No date	1F	39.72	N 116.33	W	CA
<i>sinensis</i>	Guangdong: Guangzhou	30 Sep 1961	1 F	23.12	N 113.25	W	CA
<i>sinensis</i>	Guangdong: Guangzhou, Yangjiang	Jun 1956	2F	23.12	N 113.25	W	IM
<i>sinensis</i>	Guangdong: Zhuhai	No date	1F	22.28	N 113.57	W	CA
<i>sinensis</i>	Guangxi: Baise	1 Jul 1957	1F	23.82	N 106.45	W	IM
<i>sinensis</i>	Guangxi: Beihai	12 Aug 1974	1F	21.48	N 109.10	W	IM
<i>sinensis</i>	Guangxi: Bobai	13 Sep 1957	1F	22.28	N 109.97	W	IM
<i>sinensis</i>	Guangxi: Daxin	Oct 1957	4F	22.84	N 107.20	W	IM
<i>sinensis</i>	Guangxi: Dongxing	5 May, 7, 16 Aug 1974	4F	21.55	N 107.97	W	IM
<i>sinensis</i>	Guangxi: Fuying	22 Jun 1957	1F	24.83	N 111.27	W	IM
<i>sinensis</i>	Guangxi: Guilin	29 Jun, 8, 29 Jul, 25 Aug 1967	4F	25.28	N 110.28	W	IM
<i>sinensis</i>	Guangxi: Longrui	6 Dec 1990	2 F	22.22	N 107.07	W	CA
<i>sinensis</i>	Guangxi: Longzhou	11 Sep 1974	1F	22.35	N 106.86	W	IM
<i>sinensis</i>	Guangxi: Mobian	14 May, 9 Jun 1957	11F; 1M	22.45	N 107.31	W	IM
<i>sinensis</i>	Guangxi: Munan	13 Jul 1957	1F	21.98	N 106.72	W	IM

To be continued.

TABLE 1. (continued)

Anopheles Species	Province: Locality	Collection date	No. and stage ¹	Grid Coordinates ²			Repository ³
				Latitude	Longitude		
<i>sinensis</i>	Guangxi: Nanning	Dec 1956	1F	22.82	N 108.32	W	IM
<i>sinensis</i>	Guangxi: Ningming	14 Jun 1957; 4 Sep 1974	2F	22.13	N 107.07	W	IM
<i>sinensis</i>	Guangxi: Pingguo	1 Sep 1957	1F	23.91	N 106.46	W	IM
<i>sinensis</i>	Guangxi: Pingle	Oct 1959	2F	22.54	N 110.27	W	IM
<i>sinensis</i>	Guangxi: Pingxiang	25-30 Apr, 20 May, 1 Jul 1957; 29 Aug 1974	4F; 2M	22.66	N 106.76	W	IM
<i>sinensis</i>	Guangxi: Pingxiang	5, 11 Dec 1986	4 F	22.66	N 106.76	W	CA
<i>sinensis</i>	Guangxi: Tiandong	14 Jun, 7 Sep 1957	2F, 1M	23.61	N 107.12	W	IM
<i>sinensis</i>	Guangxi: Xiakou	Oct 1957	1F	24.68	N 107.73	W	IM
<i>sinensis</i>	Guangxi: Xingan	13 Sep 1957	1F	25.62	N 110.67	W	IM
<i>sinensis</i>	Guangxi: Yulin	16, 20 Sep 1957	2F	22.63	N 110.15	W	IM
<i>sinensis</i>	Guizhou: Ergezhai, Guiyang	12 Aug 2005	11F, 12M, 1L	26.58	N 106.72	W	FC
<i>sinensis</i>	Guizhou: Guiyang	Jun 1955	3F	26.92	N 108.73	W	IM
<i>sinensis</i>	Hainan: Dengmai	No date	1F	18.70	N 109.45	W	CA
<i>sinensis</i>	Hainan: Lingshui	No date	1F	18.52	N 110.02	W	CA
<i>sinensis</i>	Hainan: Ya	No date	1F	18.23	N 109.48	W	CA
<i>sinensis</i>	Hainan: Yulin	Nov 1981	4F	18.23	N 109.53	W	SM
<i>sinensis</i>	Heilongjiang: Raohe	3, 4, 24 Jul 1982	2F, 1M	46.80	N 134.02	W	IM
<i>sinensis</i>	Heilongjiang: Tahe	2 Aug 1975	1 F	52.33	N 124.73	W	CA
<i>sinensis</i>	Henan: Funiu	17 Sep 1990	9 F	33.70	N 112.30	W	CA
<i>sinensis</i>	Henan: Tanghe	Jul 2001	1F	33.85	N 111.12	W	SM
<i>sinensis</i>	Henan: Tongbai	10 - 13 Aug 1973; Jul 2001	5F, 1M	32.36	N 113.40	W	IM
<i>sinensis</i>	Henan: Xinyang	21-28 Jun 1973	3F, 7M	32.10	N 114.12	W	IM
<i>sinensis</i>	Henan: Xixia	6 Aug 1973	1F	33.29	N 111.47	W	IM
<i>sinensis</i>	Henan: Zhengzhou	No date	1F	34.76	N 113.65	W	CA
<i>sinensis</i>	Hubei: Changyang	21 Sep 1957	3F	30.47	N 111.19	W	IM
<i>sinensis</i>	Hubei: Junxian	1957	5F	32.54	N 111.51	W	IM
<i>sinensis</i>	Hubei: Wufeng	1957	1F	30.20	N 110.60	W	IM
<i>sinensis</i>	Hubei: Xiangyang	18 Jun 1957	2F, 1M	32.04	N 112.15	W	IM
<i>sinensis</i>	Hubei: Xiaogan	1957	6F	30.92	N 113.90	W	IM
<i>sinensis</i>	Hubei: Yinshan	1957	5F	31.62	N 113.82	W	IM
<i>sinensis</i>	Hubei: Yunxian	1957	11F	32.81	N 110.81	W	IM
<i>sinensis</i>	Hubei: Zigui	1957	6F	31.02	N 110.58	W	IM
<i>sinensis</i>	Jiangsu: Huaian	Nov 2004	3F	33.50	N 119.14	W	FC
<i>sinensis</i>	Jiangsu: Huaiyin	19 Jul 1970	2F	33.59	N 119.02	W	IM
<i>sinensis</i>	Jiangsu: Jiajiang	5 Aug 1975	2F	31.45	N 121.09	W	IM
<i>sinensis</i>	Jiangsu: Jintan	19 Jul 1970	2F	31.75	N 119.58	W	IM

To be continued.

TABLE 1. (continued)

Anopheles Species	Province: Locality	Collection date	No. and stage ¹	Grid Coordinates ²			Repository ³
				Latitude	Longitude		
<i>sinensis</i>	Jiangsu: Nanjing	No date	1F	32.06	N 118.78	W	SM
<i>sinensis</i>	Jiangsu: Nanjing, Liuhe	29 Jul 2005	1M, 3L	32.06	N 118.78	W	FC
<i>sinensis</i>	Jiangsu: Nanjing, Maji	29 Jul 2005	30F	32.06	N 118.78	W	FC
<i>sinensis</i>	Jiangsu: Sinho, Sihong	19 July 1970	3F	33.46	N 118.21	W	IM
<i>sinensis</i>	Jiangsu: Sinho, Sihong	27 Jul 2005	5F, 5M, 1L	33.46	N 118.21	W	FC
<i>sinensis</i>	Jiangsu: Sinho, Tiam Gan Hu	27 Jul 2005	33 F	33.46	N 118.21	W	FC
<i>sinensis</i>	Jiangsu: Suzhou	19 Jul 1970	9F	31.93	N 118.98	W	IM
<i>sinensis</i>	Jiangsu: Wujing	Jul 1997	1F	31.78	N 119.97	W	SM
<i>sinensis</i>	Jiangsu: Wujing	No date	1F	31.78	N 119.97	W	CA
<i>sinensis</i>	Jiangsu: Wuxi	31 Jul 2005	7F, 13M, 12P, 14L, 2LE	31.58	N 120.29	W	FC
<i>sinensis</i>	Jiangsu: Wuxi	No date	1F	31.58	N 120.29	W	CA
<i>sinensis</i>	Jiangsu: Xinhailian	19 Jul 1970	3F	31.92	N 121.17	W	IM
<i>sinensis</i>	Jiangsu: Xuyi Co., Quiji	28 Jul 2005	5F, 12M, 10P, 10L	33.01	N 118.49	W	FC
<i>sinensis</i>	Jiangsu: Xuyi Co., Xu Chen Zheng	28 Jul 2005	2M, 1L	33.01	N 118.49	W	FC
<i>sinensis</i>	Jiangsu: Xuzhou	Jul 1960; 19 Jul 1970	1M; 6F	34.27	N 117.19	W	IM
<i>sinensis</i>	Jianxi: Nanchang	1 May 1955	1F	28.68	N 115.88	W	IM
<i>sinensis</i>	Jilin: Baicheng	9 Jul 1958	5F	45.62	N 122.82	W	IM
<i>sinensis</i>	Liaoning: Faku	No date	1F	42.50	N 123.41	W	CA
<i>sinensis</i>	Liaoning: Shenyang	No date	1F	41.79	N 123.43	W	CA
<i>sinensis</i>	Ningxia: Yinchuan	2-25 Aug, 2 Sep 1972	7F	38.47	N 106.27	W	IM
<i>sinensis</i>	Ningxia: Zhongwei	8 Aug 1972	1F	37.52	N 105.18	W	IM
<i>sinensis</i>	Shaanxi: Danfeng	No date	2F	33.75	N 110.30	W	CA
<i>sinensis</i>	Shaanxi: Danfeng Co., Qinling Mt.	20 Aug 1996	4F, 1M	33.75	N 110.30	W	SM
<i>sinensis</i>	Shaanxi: Nichuan Co.	No date	2F, 1M	34.14	N 107.30	W	SM
<i>sinensis</i>	Shandong: Changs- han	9 Jun 1960	1F	36.88	N 117.83	W	IM
<i>sinensis</i>	Shandong: Fangzi	16 Jun 1960	1F	36.60	N 119.15	W	IM
<i>sinensis</i>	Shandong: Haiyang	11 Jul 1960	1F	36.78	N 121.16	W	IM
<i>sinensis</i>	Shandong: Jiaonan	20 Aug 1960	1F, 1M	35.88	N 119.98	W	IM

To be continued.

TABLE 1. (continued)

Anopheles Species	Province: Locality	Collection date	No. and stage ¹	Grid Coordinates ²			Repository ³
				Latitude	Longitude		
<i>sinensis</i>	Shandong: Jinan	23 Jun 1960	1F	36.67	N 117.00	W	IM
<i>sinensis</i>	Shandong: Jining	No date	1F	35.41	N 116.58	W	CA
<i>sinensis</i>	Shandong: Linyi	1 Aug 1960; Aug 2001	1F	35.06	N 118.34	W	IM
<i>sinensis</i>	Shandong: Nanyang	23 Jun 1960	1F	35.09	N 116.67	W	IM
<i>sinensis</i>	Shandong: Pingdu	23 Aug 1960	1F	36.78	N 119.95	W	IM
<i>sinensis</i>	Shandong: Qiaoshan-wei	27 Aug 1960	2F	36.25	N 116.77	W	IM
<i>sinensis</i>	Shandong: Qingdao	30 Aug 1960	1M	36.10	N 120.37	W	IM
<i>sinensis</i>	Shandong: Rizhao	Jul 1960	1M	35.43	N 119.46	W	IM
<i>sinensis</i>	Shandong: Weifang	30 Jul 1960	1F	36.71	N 119.10	W	IM
<i>sinensis</i>	Shandong: Wendeng	16 Jul 1960	1F	37.19	N 122.05	W	IM
<i>sinensis</i>	Shandong: Yantai	2, 22 Aug 1960	2F	37.53	N 121.40	W	IM
<i>sinensis</i>	Shandong: Yidu	13, 18 Aug 1960	2F	36.70	N 118.48	W	IM
<i>sinensis</i>	Shanghai	8 Aug 1988	2F, 1M	31.11	N 121.37	W	SM
<i>sinensis</i>	Sichuan: Dukou	20, 24-26 Jun 1975	1M, 3F	26.55	N 101.73	W	IM
<i>sinensis</i>	Sichuan: Emei	16 Jul 1975	2F	29.58	N 103.52	W	IM
<i>sinensis</i>	Sichuan: Ershan	22, 23 Jul 1975	2F	32.59	N 103.05	W	IM
<i>sinensis</i>	Sichuan: Hongya	8 Aug 1975	1F	29.93	N 103.42	W	IM
<i>sinensis</i>	Sichuan: Huidong	No date	1F	26.65	N 102.58	W	CA
<i>sinensis</i>	Sichuan: Huili	4 Jul 1975	1F	26.68	N 102.25	W	IM
<i>sinensis</i>	Sichuan: Jiajiang	15 Jul, 15 Aug 1975	5F	29.75	N 103.58	W	IM
<i>sinensis</i>	Sichuan: Linan	Aug 1961	1F	30.97	N 107.07	W	IM
<i>sinensis</i>	Sichuan: Meigu	13, 14 Jul 1975	5F, 2M	28.33	N 103.13	W	IM
<i>sinensis</i>	Sichuan: Mingshan	30 Jul 1975	1F	30.13	N 103.17	W	IM
<i>sinensis</i>	Sichuan: Miyi	25, 29 Jun 1975	2F, 1M	26.83	N 102.05	W	IM
<i>sinensis</i>	Sichuan: Ningnan	18 Jun 1975	2F	27.07	N 102.76	W	IM
<i>sinensis</i>	Sichuan: Pixian	No date	1F	30.80	N 103.88	W	CA
<i>sinensis</i>	Sichuan: Pujiang	Jul 1997	1F	30.20	N 103.50	W	CA
<i>sinensis</i>	Sichuan: Xichang	13-18 Jun 1975	3F, 3M	27.90	N 102.27	W	IM
<i>sinensis</i>	Sichuan: Yaan	28, 29 Jul, 6 Aug 1975	2F	29.98	N 103.08	W	IM
<i>sinensis</i>	Sichuan: Zhaomian	14 Jul 1975	2M	31.58	N 105.43	W	IM
<i>sinensis</i>	Xinjiang: Yili	No date	1F	43.52	N 83.30	W	CA
<i>sinensis</i>	Yunnan: Gejiu	4 Aug 1990	3 F	23.37	N 103.16	W	CA
<i>sinensis</i>	Yunnan: Jiangchengxian	1 Aug 1990	1 F	26.47	N 99.87	W	CA
<i>sinensis</i>	Yunnan: Kaiyuan	No date	1F	23.71	N 103.25	W	CA
<i>sinensis</i>	Yunnan: Kunming	No date	1F	25.04	N 102.72	W	CA
<i>sinensis</i>	Yunnan: Kunming, Jungli	10 Aug 2005	11F, 7M	25.04	N 102.72	W	FC

To be continued.

TABLE 1. (continued)

Anopheles Species	Province: Locality	Collection date	No. and stage ¹	Grid Coordinates ²			Repository ³
				Latitude	Longitude		
<i>sinensis</i>	Yunnan: Kunming, Majungli	10 Aug 2005	2F, 1PE	25.04	N 102.72	W	FC
<i>sinensis</i>	Yunnan: Luchunxian	9 Aug 1990	2 F	23.32	N 102.17	W	CA
<i>sinensis</i>	Yunnan: Mengla	16 Sep 1990	5 F	21.47	N 101.58	W	CA
<i>sinensis</i>	Yunnan: Mengla	2 Jul 1976	5F, 1M	21.47	N 101.58	W	IM
<i>sinensis</i>	Yunnan: Simao	15 Aug 1986	4 F	22.77	N 101.08	W	CA
<i>sinensis</i>	Yunnan: Simao	2 Jul 1976; May 1997	5F	22.77	N 101.08	W	IM
<i>sinensis</i>	Yunnan: Wenshan-zhen	No date	1F	23.37	N 104.23	W	CA
<i>sinensis</i>	Yunnan: Yuanyangxian	7 Aug 1990	3 F	23.22	N 102.68	W	CA
<i>sinensis</i>	Zhejiang: Dinghai	22 Aug, 3 Sep 1954	2F	30.02	N 122.10	W	IM
<i>sinensis</i>	Zhejiang: Hangzhou	13 Jul 1960	5 F	30.26	N 120.17	W	CA
<i>sinensis</i>	Zhejiang: Huangyan	30 Jun, 30 Sep 1955	3F	27.75	N 119.99	W	IM
<i>sinensis</i>	Zhejiang: Huzhou	Jun 1956	1F	30.87	N 120.10	W	IM
<i>sinensis</i>	Zhejiang: Linan	Aug 1968; 11 Jul 1978; May 2000	5F, 1M; 3F	30.24	N 119.72	W	IM
<i>sinensis</i>	Zhejiang: Moganshan	4-6 Jul 1978	6F	30.60	N 119.87	W	IM
<i>sinensis</i>	Zhejiang: Tianmushan	1, 4, 20, 29 Jul 1978	4F	30.30	N 119.39	W	IM
<i>sineroides</i>	Jilin: Jian	23 Oct 1952	1F	41.12	N 126.18	W	IM
<i>sineroides</i>	Liaoning: Xiuyan	15 Jun 1958	1F	40.29	N 123.27	W	IM
<i>sineroides</i>	Liaoning: Xiuyan	14 Jul 1958	1F	40.29	N 123.27	W	IM
<i>sineroides</i>	Liaoning: Xiuyan	23 Sep 1958	1F	40.29	N 123.27	W	IM
<i>sineroides</i>	Liaoning: Zhuanghe	14 Jul 1958	1F	39.70	N 122.99	W	IM
<i>sineroides</i>	Liaoning: Zhuanghe	26 Aug 1973	4F, 2M	39.70	N 122.99	W	IM

¹F, adult female; Ge, male genitalia; L, whole larva; Le, larval exuviae; M, adult male; P, whole pupa; Pe, pupal exuviae; D, DNA material.

²Coordinates expressed as degrees and decimals of degrees.

³CA = Entomology Museum, Chinese Academy of Sciences (Institute of Zoology), Beijing;

FC = Field collected, deposited in Smithsonian Institution (Natural History Museum), Washington, D. C.;

IM = Entomology Museum, Beijing Institute of Microbiology and Epidemiology, Beijing;

SM = Entomology Collection, Second Military Medical Univ. (Department of Etiologic Biology), Shanghai.

Anopheles belenrae was originally reported from South Korea (Rueda 2005; Rueda *et al.* 2006). Based on morphological examinations of specimens and rDNA-ITS2 sequence comparisons, we determined that *An. belenrae* is the same as *An. unknown* "sp. 2" of Ma & Xu (2005). The status of *An. belenrae* as a malaria vector in China is unknown. Ma & Xu (2005) also reported *An. unknown* "sp. 1" (collection data: 3 females, from Rongcheng, Shandong, June 1991; GenBank accession number AY 306128; deposited at the Entomology Collection, Department of Etiologic Biology, Second Military Medical University, Shanghai). The true identity of this species is not yet determined and additional specimens are needed for further morphological and molecular analysis.

TABLE 2. *Anopheles Hyrcanus* Group species previously recorded and observed from 24 provinces and 2 cities of China.

Anopheles Species	Province (Reference)
<i>argyropus</i>	25*(P3)**
<i>belenrae</i>	17(P2, X), 20 (P2, X)***
<i>changfus</i>	23(P6)
<i>crawfordi</i>	25(P2)
<i>dazhaius</i>	23(X)
<i>hailarensis</i>	18(P5)
<i>heiheensis</i>	10(P3, P6, P7)
<i>hyrcanus</i>	24(P2, P4, X)
<i>junlianensis</i>	23(P2, P7)
<i>kiangsuensis</i>	14(P3)
<i>kunmingensis</i>	23(X), 25(P2, X)
<i>kweiyangensis</i>	1(P3, P4), 3(P3, P4), 6(P3, P4), 7(P4, X), 11(P4, X), 12(P3, P4), 13(P3, P4), 17(X), 23(P2, P4, X), 25(P4), 26(X)
<i>lesteri</i> (= <i>anthropophagus</i>)	1(P3), 3(P4), 5(P3, P4, X), 6(P2, P4), 7(P3, P4), 8(P2, P4), 11(P2, P4), 12(P4), 13(P3, P4), 14(P4, X), 15(P4), 17 (P2), 23(P4), 25(P3, P4), 26(P4)
<i>liangshanensis</i>	23(P2, P4, X), 25(P4, X)
<i>nigerrimus</i>	3(P3, P4), 6(P3, P4), 7(P3, P4), 15(P3, P4), 25(P3, P4)
<i>nitidus</i>	6(P3)
<i>peditaeniatius</i>	3(P4, X), 6(P4, X), 7(P3), 8(P4, X), 25(P2, P4, X)
<i>pullus</i>	7(P4, X), 9(P3, P4), 10 (P4, P7, X), 11(P2, P4), 14(P3, P4), 16(P3, P4), 17(P2, P4, X), 18(P3, P4), 20(P4, X), 22(P3, P4), 23(P2, P4, X), 25(P3, P4)
<i>sinensis</i>	1 (P1, X), 2(P1, X), 3(P1), 4(X), 5(P1, X), 6(P1, X), 7(P1, X), 8(P1, X), 10 (P1, X), 11(P1, P2, X), 12(X), 14(P1, P2, X), 15(X), 16(X), 17(P1), 19(X), 20(P1, P2, X), 21(X), 22(P1, X), 23(P1, P2, X), 24(P1, X), 25(P1, P2, X), 26(P1, P2, X)
<i>sineroides</i>	16(X), 17(X)
<i>xiaokuanus</i>	10(P6)

*Provinces: 1 = Anhui; 2 = Beijing; 3 = Fujian; 4 = Gansu; 5 = Guandong; 6 = Guangxi; 7 = Guizhou; 8 = Hainan; 9 = Hebei; 10 = Heilongjiang; 11 = Henan; 12 = Hubei; 13 = Hunan; 14 = Jiangsu; 15 = Jiangxi; 16 = Jilin; 17 = Liaoning; 18 = Inner Mongol; 19 = Ningxia; 20 = Shandong; 21 = Shanghai; 22 = Shaanxi; 23 = Sichuan; 24 = Xinjiang; 25 = Yunnan; 26 = Zhejiang.

**References: P1 = Rueda et al (2005); P2 = Ma and Xu (2004); P3 = Lu et al (1997); P4 = Lu and Yong (2003); P5 = Xu and Luo (1998); P6 = Ma (1981); P7 = Lei (1996); P8 = Ma and Yu (1993); X = observed in this survey.

***Listed as *Anopheles* unknown "sp. 2" by Ma and Xu (2005).

In this paper, we followed Harbach (2004) and Ma & Xu (2005) for the list of known species, except for inclusion of a few species (i.e., *An. dazhaius*, *kiangsuensis*, and *xiaokuanus*) for which further studies are needed to resolve their taxonomic validity. A list of the Hyrcanus group, with valid species and their synonyms is also found in the mosquito catalog at the Walter Reed Biosystematics Unit website (<http://www.mosquitocatalog.org/main.asp>). Ma & Xu (2005) reported 12 species of the group in China, with their synonyms, based on the sequences of the second internal transcribed spacer (ITS2) of ribosomal DNA. Wilkerson *et al.* (2003), Rueda *et al.* (2005b) and Ma & Xu (2005) considered *An. anthropophagus* to be a junior synonym of *An. lesteri*. Harbach (2004) agreed and excluded *An. anthropophagus* from his list of valid Hyrcanus group species. Rueda *et al.* (2005b) designated and described the neotype of *An. lesteri* from the new type

locality (Calauan, Laguna, Philippines) to clarify and stabilize the taxon. This new type locality is where the "cotypes" of the original *lesteri* were collected in 1936 (Baisas and Hu 1936). As stated in the International Code of Zoological Nomenclature (ICZN 1999), Article 76.3, page 87, the place of origin of the neotype becomes the type locality of the species-group taxon, despite any previously published statement of the type locality. Rueda *et al.* (2005b) provided detailed descriptions and illustrations of the *An. lesteri* neotype and associated specimens, particularly the larval and pupal stages, adult female and male genitalia, as well as the rDNA ITS2 sequence (GenBank accession number AY375469).

Anopheles kunmingensis may be a synonym of *An. liangshanensis* based on rDNA ITS2 sequence, morphological comparisons (Ma *et al.* 2000) and on cross-hybridization experiments (Kang *et al.* 1992). However, Ma & Xu (2005) reconsidered these two species as valid. The type localities of *An. kunmingensis* and *An. liangshanensis* are in the provinces of Yunnan and Sichuan, respectively. Our examination of collection data from museum specimens revealed that *An. kunmingensis* and *An. liangshanensis* occur in both provinces. Although they have distinct morphological features, extreme care must be taken in selecting specimens as DNA sources for sequence analysis. It is not uncommon to find misidentified specimens with their sequences reported. Until further studies can help resolve these uncertainties, we consider both *An. kunmingensis* and *An. liangshanensis* to be valid species.

We also attempted to check the status of the type specimens of 11 species of the Hyrcanus group originally collected from China. Yang *et al.* (1991) reported that the holotypes, allotypes, and paratypes of four species (*An. changfus*, *An. dazhaius*, *An. heiheensis*, *An. xiaokuanus*) are in the Institute of Zoology, Chinese Academy of Science, Beijing but they could not be located (Rueda *et al.* 2005a). In 2005, LMR visited the type localities of *An. kunmingensis* in Kunming, Yunnan and *An. kweiyangensis* in Guiyang, Guizhou but failed to collect specimens of those species. Additional collections by LMR in 2005 from near the type localities of *An. kiangsuensis* and *An. liangshanensis* in the provinces of Jiangsu and Sichuan, respectively, failed to yield specimens of either species. The location of the type specimens of *An. kweiyangensis* is unknown, and further inquiries failed to locate the types of the remaining species from reported depositories.

Because of the absence of type specimens, it is extremely difficult to determine the validity of some Hyrcanus group species. There is an urgent need to recover the missing type specimens, or if not possible, to replace them (e.g. with neotypes) in order to stabilize the whole group. Type specimens (or associated specimens) could be used for both molecular and morphological comparisons of questionable species. These may help to solve the taxonomic problems and other identification challenges of the group.

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